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Inventory Model with Time-Dependent Holding cost under Inflation when Seller Credits to Order Quantity

Rajendra Sharma[1], Jasvinder Kaur[2]

Department Of Mathematics, Graphic Era University Dehradun (UK), India

Email: rs.2103@yahoo.in, jasvinddn@gmail.com

Abstract

In this study an inventory model is developed under which the seller provides the retailer a permissible delay in payments, if the retailer orders a large quantity. In this paper we establish an inventory model for non deteriorating items and time dependent holding cost under inflation when seller offers permissible delay to the retailer, if the order quantity is greater than or equal to a predetermined quantity. We then obtain optimal solution for finding optimal order quantity, optimal replenishment time and optimal total relevant cost. Finally, numerical example is given to illustrate the theoretical results and made sensitive analysis of various parameters on the optimal solution.

Keywords: Inventory; inflation; order quantity; time dependent holding cost.

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I. Introduction

In inventory management, one of the important problems is how to maintain and control the inventories of deteriorating items. Deterioration refers to spoilage of material with time. Food items, radioactive materials, chemicals, green vegetables and blood are few examples of such items. In classical inventory models it is considered that the demand rate is either constant or time dependent but independent of the stock status. In recent years, mathematical ideas have been used in different areas in real life problems, particularly inventory. One of the most important concerns of the managements is the decide when and how much to order or to manufacture so that the total cost associated with the inventory system should be minimum.

Selling Price plays an important role in inventory system. Burwell et al. [1] developed economic lot size model for dependent demand rate under quantity and freight discount. An inventory model with price and time dependent demand is developed by mandal et al. [2] and you [3]. Chang et al. [4] developed an EOQ model when supplier offers trade credit to the buyer if the order quantity is greate than or equal to a pre-determined quantity. Chang and Huang [5] presented a model optimal ordering policy under conditions of allowable shortages and permissible delay in payments.

In most of the models, holding cost is taken as constant. But in real life and from marketing point of view holding cost may not be constant. Various function describing holding cost were considered by several researchers like Muhdlemann, A.P. and valtis spamopoulos [6], weiss [7], and Goh [8]. Patra et al. [9] developed a generalized EOQ model for deteriorating items where deterioration rate and holding cost are expressed as linearly increasing functions of time and demand rate is a function of selling price. Alferes [10] developed inventory model with stock level dependent demand rate and variable holding cost. In model [10] the holding cost is an increasing step function of the time spent in storage. In model [10] two types of time dependent holding cost increase functions are considered ie. Retroactive increase and incremental increase.

In most of the business transaction, the supplier will offer the trade terms mixing cash discount and trade credit to the customer. The concept of inflation and time value of money was employed by wee and law [11] into a model when the demand is price dependent and storage is allowed. In modal [11] a production environment with a finite replenishment rate was considered. A note on EOQ model under cash discount and payment delay was discussed by huang [12]. Jaggi et al [13] developed a model optimal order policy for deteriorating items with inflations induced demand .In model [13] the demand rate is assumed to be a function of inflation. An inventory model for deteriorating items with stock-dependent consumption rate and shortages under inflation and time discounting was developed by Hou [14]. In this paper Hou [14] discussed an inventory model for deterioration items with stock dependent consumption rate and shortage under inflation and time- discounting over a finite planning horizon. Hou and Lin [15] developed a cash flow oriented EOQ model with deteriorating items under permissible delay in payments. In this study Hou and Lin applied the discounted cash flows approach for problem analysis chung [16] presented the discounted cash flows (DCF) approach for the analysis of optimal inventory policy in the presence of the trade credit. Jsggi and Aggarwal [17] extended chung [16] to develop an inventory model for obtaining the optimal order quantity of deteriorating items in the presence of trade credit using DCF approach. Jaggi et al [18] presented retailer's optimal ordering policy under two stage trade credit financing. In paper [18] an inventory model under two levels of trade credit policy by assuming that demand is a function of credit period offered by the retailer to the customer using discounted cash flow (DCF) approach is developed.

This study develops a deterministic inventory model for non deteriorating items and time dependent holding cost. Four different cases have been discussed. The effect of inflation is also discussed. In addition optimal solution is given for cycle time, total costs and order quantity.

The rest of the paper is organized as follows: in section 2, assumptions and notations are given. Sections 3, deals with development of mathematical model. In section 4, theoretical results are given followed by numerical example in section 5. In section 6, sensitivity analysis is given. Finally, conclusion and future research directives are given in the last section.

II. Proposed Assumptions & Notations

1. Assumptions

1.1 The demand is known and is constant.

1.2 The inflation rate is a constant

1.3 Replenishment is instantaneous

1.4 Shortages are not allowed

1.5 Holding cost is time dependent i.e. $h = h(t) = ht$

1.6 If $Q<Q_d$ then the payment for the items received must be made immediately

1.7 If $Q \geq Q_d$ then the delay in payments up to M is permitted. During the trade credit period the account is not settled and generated sales revenue is deposited in an interest bearing account. At the end of credit period, the customer pays off all units ordered, and starts paying for the interest charges on the items in stocks.

2. NOTATIONS:

2.1 H : length of planning horizon and $H = nT$, where n is an integer for the number of replenishments to be made during period H and T is an interval of time between replenishments.

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2.2 h : holding cost per unit time i.e. h(t) = ht

2.3 I(t) : Inventory level at any time t, $0 \le t \le T$.

2.4 r : constant rate of inflation, $0 < r < 1$

2.5 D : the demand rate per unit time.

2.6 $P(t) = pe^{rt}$: the selling price per unit time, p is the initial selling price at t=0.

2.7 $S(t) = se^{rt}$: the ordering cost per order at time t, s is the initial ordering cost at t=0.

2.8 $C(t) = ce^{rt}$: the purchasing cost at time t, c is the initial purchase price at t=0, c < p.

2.9 I_c : interest charged / \$ / year by the supplier per order.

2.10 I_d : the interest earned / \$ /year.

2.11 Q : order quantity.

2.12 Q_d : minimum order quantity for which the delay in payments is allowed.

2.13 T : the replenishment time interval.

2.14 T_d : the time interval that Q_d units are depleted to zero due to demand only.

2.15 Z(t) : the total relevant cost over (o, H).

Note that the total relevant cost consists of (i) cost of placing order, (ii) cost of purchasing, (iii) cost of carrying inventory excluding interest charges, (iv) cost of interest charges for unsold items at t = 0 or after credit period M and (v) interest earned from sales revenue during the credit period.

III. Mathematical Formulation and Equations

The level of inventory I(t) gradually decreases mainly to meet demands only. Thus, the rate of charge of inventory with respect to time can be described by the following differential equations:

$$\frac{dI(t)}{dt} = -D, \quad 0 \le t \le T \tag{1}$$

The solution of (1), with boundary condition I(t) = 0 is

$$I(t) = D(T - t), \quad 0 \le t \le T \tag{2}$$

And the order quantity is

$$Q = I(0) = DT \tag{3}$$

From the above equation (3) we can find the time interval in which Q_d units are depleted to zero due to demand only

$$T_d = \frac{Q_d}{D} \tag{4}$$

Hence it is easy to see that the inequality

$$Q < Q_d \text{ iff } T < T_d$$

Again the length of time intervals are all the same, hence we have

$$I(KT + t) = D(T - t), \quad 0 \le k \le n - 1, \quad 0 \le t \le T \tag{5}$$

For total relevant cost in (0,H), we need following elements

(i) cost of placing order

$$S(0) + S(T) + S(2T) + \ldots\ldots\ldots\ldots\ldots\ldots. + S\{(n-1)T\} = S\left(\frac{e^{rH}-1}{e^{rT}-1}\right) \tag{6}$$

(ii) cost of purchasing

$$Q[C(0) + C(T) + C(2T) + \ldots\ldots\ldots\ldots\ldots + C\{(n-1)T\}] = CDT\left(\frac{e^{rH}-1}{e^{rT}-1}\right) \tag{7}$$

(iii) cost of carrying inventory

$$\sum_{K=0}^{n-1} C(K,T) \int_0^T h(t).I(KT + t)dt = chD\frac{T^3}{6}\left(\frac{e^{rH}-1}{e^{rT}-1}\right) \tag{8}$$

(iv) Regarding interest charged and earned, we have the following four possible cases based on the values of T, M and T_d

Case I, $0 < T < T_d$

Since T< T_d (i.e. Q< Q_d). In this case the interest charges for all unsold items start at the initial time, we obtain the interest payable in (0,H) as

$$I_C \sum_{k=0}^{n+1} C(K,T) \int_0^T I(KT+t)dt \ = \frac{T^2}{2} I_C cD \left(\frac{e^{rH}-1}{e^{rT}-1}\right) \tag{9}$$

$\therefore\ Z_1(T) =$ total cost in (0,H)

$$Z_1(T) = \left[s + cDT + chD\frac{T^3}{6} + I_C cD\frac{T^2}{2}\right]\left(\frac{e^{rH}-1}{e^{rT}-1}\right) \tag{10}$$

Case II, $T_d \leq T < M$

In this case there is a permissible delay M which is longer than T. As a result there is no interest charged, but the interest earned in (0,H) is

$$I_d \sum_{k=0}^{n-1} P(K,T) \left[\int_0^T Dt\, dt + DT(M-T)\right] = I_d PD \left(TM - \frac{T^2}{2}\right)\left(\frac{e^{rH}-1}{e^{rT}-1}\right) \tag{11}$$

$\therefore\ Z_2(T) =$ total relevant cost in (0,H)

$$Z_2(T) = \left[s + cDT + chD\frac{T^3}{6} - I_d PD\left(TM - \frac{T^2}{2}\right)\right]\left(\frac{e^{rH}-1}{e^{rT}-1}\right) \tag{12}$$

Case III, $T_d \leq M \leq T$

In this case, T is longer than or equal to both T_d and M then delay in payment is permitted and the total relevant cost includes both the interest charged and the interest earned. The interest payable in (0,H) is

$$I_c \sum_{k=0}^{n-1} C(K,T) \int_M^T I(KT+t)dt \ = \frac{1}{2} cD(T-M)^2 \left(\frac{e^{rH}-1}{e^{rT}-1}\right) \tag{13}$$

The interest earned in (0,H) is

$$I_d \sum_{k=0}^{n-1} P(K,T) \int_0^M Dtdt \ = I_d pD\frac{M^2}{2}\left(\frac{e^{rH}-1}{e^{rT}-1}\right) \tag{14}$$

$\therefore\ Z_3(T) =$ total relevant cost in (0,H)

$$Z_3(T) = \left[s + cDT + chD\frac{T^3}{6} + \frac{1}{2} I_c cD(T-M)^2 + I_d PD\frac{M^2}{2}\right]\left(\frac{e^{rH}-1}{e^{rT}-1}\right) \tag{15}$$

Case IV, $M \leq T_d \leq T$

In this case, the replenishment time interval T is also greater than or equal to both T_d and M. Hence case IV is similar to case III. Thus total relevant cost in (0,H) is

$$Z_4(T) = \left[s + cDT + chD\frac{T^3}{6} + \frac{1}{2} I_c cD(T-M)^2 + I_d PD\frac{M^2}{2}\right]\left(\frac{e^{rH}-1}{e^{rT}-1}\right) \tag{16}$$

IV. Theoretical Results

Since inflation rate r is very small. Using truncated taylor's series expansion for the exponential terms, we get the modified (approximated) values of $Z_i(T)$,i =1, 2, 3 & 4 as follows

$$Z_1(T) \approx \frac{1}{r}\left[\frac{S}{T} + cD + chD\frac{T^2}{6} + I_c cD\frac{T}{2}\right](e^{rH}-1), \quad (\because e^{rT} \approx 1 + Rt) \tag{17}$$

$$Z_2(T) \approx \frac{1}{r}\left[\frac{S}{T} + cD + chD\frac{T^2}{6} - I_d pD\left(M - \frac{T}{2}\right)\right](e^{rH}-1) \tag{18}$$

$$Z_3(T) \approx \frac{1}{r}\left[\frac{S}{T} + cD + chD\frac{T^2}{6} + \frac{1}{2} I_c cD\left(T + \frac{M^2}{T} - 2M\right) + \frac{I_d PDM^2}{2T}\right](e^{rH}-1) \tag{19}$$

$$Z_4(T) \approx \frac{1}{r}\left[\frac{S}{T} + cD + chD\frac{T^2}{6} + \frac{1}{2} I_c cD\left(T + \frac{M^2}{T} - 2M\right) + \frac{I_d PDM^2}{2T}\right](e^{rH}-1) \tag{20}$$

The optimal solutions are obtained by taking the first and second order derivatives of $Z_i(T)$,i =1,2,3&4 with respect to T, we obtain

$$\frac{dZ_1(T)}{dT} = \frac{1}{r}\left[-\frac{S}{T^2} + \frac{chDT}{3} + \frac{I_c cD}{2}\right](e^{rH}-1) \tag{21}$$

$$\frac{dZ_2(T)}{dT} = \frac{1}{r}\left[-\frac{S}{T^2} + \frac{chDT}{3} + \frac{I_d pD}{2}\right](e^{rH}-1) \tag{22}$$

$$\frac{dZ_3(T)}{dT} = \frac{1}{\mathrm{r}}\left[-\frac{S}{T^2} + \frac{chDT}{3} + \frac{I_c cD}{2}\left(1 - \frac{\mathrm{M}^2}{\mathrm{T}^2}\right) - \frac{\mathrm{I_d\,PD\,M}^2}{2\mathrm{T}^2}\right](e^{rH} - 1) \tag{23}$$

$$\frac{d^2Z_1(T)}{dT^2} = \frac{1}{r}\left[\frac{2S}{T^3} + \frac{chD}{3}\right](e^{rH} - 1) > 0 \tag{24}$$

$$\frac{d^2Z_2(T)}{dT^2} = \frac{1}{r}\left[\frac{2S}{T^3} + \frac{chD}{3}\right](e^{rH} - 1) > 0 \tag{25}$$

$$\frac{d^2Z_3(T)}{dT^2} = \frac{1}{\mathrm{r}}\left[\frac{2S}{T^3} + \frac{chD}{3} + \frac{\mathrm{I_c\,CD\,M}^2}{\mathrm{T}^3} + \frac{\mathrm{I_d\,PD\,M}^2}{\mathrm{T}^3}\right](e^{rH} - 1) > 0 \tag{26}$$

For optimal (minimum) solution, put $\frac{dZ_i(T)}{dT} = 0, i = 1,2,3,4,$ we obtain

From (21) $\frac{dZ_1(T)}{dT} = 0$

$$2chDT^3 + 3I_c cDT^2 - 6s = 0 \tag{27}$$

From (22) $\frac{dZ_2(T)}{dT} = 0$

$$2chDT^3 + 3I_d pDT^2 - 6s = 0 \tag{28}$$

From (23) $\frac{dZ_2(T)}{dT} = 0$

$$2chDT^3 + 3I_c cDT^2 \; - (6S + 3\mathrm{C}I_c DM^2 + 3\mathrm{I_d PDM}^2) = 0 \tag{29}$$

V. Examples and Tables

1.NUMERICAL EXAMPLES:

Case I, $0 < T < \mathrm{T_d}$

Example 1. Let s=$ 150/order, c= $ 25/units, h=$ 2/unit/year, I_c =0.10/$/year, D=500 unit/year, p=$ 30 per unit, r =0.05 per unit, I_d=0.05/$ /year, h=1year, Substituting these values in (27) and (3) and (10) we obtain

$1000\ T^3 + 75\ T^2 - 18 = 0$ (30)

Solving (30) we get

T = $T_1^* = 0.239308525$ year

∴ optimal order quantity

Q = $Q_1^*\,(T_1^*) = DT_1^* = 500\ \times 0.239308525 = 119.6542625$ units

If Q_d = 120 units, then $T_d = \frac{Q_d}{D} = \frac{120}{500} = 0.24$ year

Which verifies that, when $Q_1^* < \ Q_d$ then $T_1^* < \ T_d$, which proves case 1

Also $Z_1^*\,(T_1^*) = \ \$\,13858.56996$

Case II, $\mathrm{T_d} \le T < M$

Example 2. let D= 100 units, θ = 0.02, c =$ 30/units, p=$ 40 per unit, h=$ 2/unit/year, I_d=0.05/$ /year, H=1year, s=$ 50/order, I_c =0.08/$/year, r=0.05 per unit, M=110days, Substituting these values in (28) and (3) and (12) we get

$2000\ T^3 + 100\ T^2 - 50 = 0$ (31)

Solving (31) we get

T = $T_2^* = 0.276649$ year

∴ optimal order quantity

Q = $Q_2^*\,(T_2^*) = DT_1^* = 27.6649$ unit

If Q_d = 25 units, then $T_d = \frac{Q_d}{D} = \frac{25}{100} = 0.25$ year

which proves case 2

Also $Z_2^*\,(T_2^*) = \ \$\,1159.8975$

Case III, $\mathrm{T_d} \le M \le T$

Example 3. let D= 100 units, c= $ 10/units, p=$ 20 per unit, h=$ 2/unit/year, I_d=0.05/$ /year, H=1year, s=$ 100/order, I_c = 0.10/$/year, M=90days, Substituting these values in (29) and (3) and (15) we get the values

$$4000\,T^3 + 300\,T^2 - 627.3596538 = 0 \quad (32)$$

Solving (32) we get

T = $T_3^* = 0.518004$ year

And corresponding optimal order quantity

Q = $Q_3^*\,(T_3^*) = 51.8004$ units

If Q_d = 50 units, then $T_d = \frac{Q_d}{D} = \frac{50}{500} = 0.5$ year

which proves case 3

Also $Z_3^*\,(T_3^*) = \$\,1328.854169$

2. SENSITIVITY ANALYSIS:

Sensitivity analysis has been performed by considering various values of the parameters like unit ordering cost (s), unit purchasing cost (c), holding cost (h) and credit period (M), the corresponding values obtained with respect to the changes in above parameters are replenishment cycle time (T), economic order quantity Q and total relevant cost Z(T) by taking into consideration the following different cases.

i. When $0 < T < T_d$ [tables 1(a),1(b),1(c)]

ii. When $T_d \leq T < M$ [tables 2(a),2(b),2(c)]

iii. When $T_d \leq M \leq T$ [tables 3(a),3(b),3(c),3(d)]

Table 1. (case 1: When $0 < T < T_d$)

Table 1(a): Sensitivity analysis on 's'

S	T_1^*	$Q_1^*\,(T_1^*)$	$Z_1^*\,(T_1^*)$
160	.244963	122.4815	13900.91739
170	.250388	125.194	13942.31781
180	.255606	127.803	13982.84756
190	.260635	130.3175	14022.57294
200	.265492	132.746	14061.55197

Table 1(b): Sensitivity analysis on 'c'

C	T_1^*	$Q_1^*\,(T_1^*)$	$Z_1^*\,(T_1^*)$
26	.235932	117.966	14387.02082
27	.232725	116.3625	14915.12194
28	.229673	114.8365	15442.89397
29	.226764	113.382	15970.35566
30	.223986	111.993	16497.52411

Table 1(c): Sensitivity analysis on 'h'

H	T_1^*	$Q_1^*\,(T_1^*)$	$Z_1^*\,(T_1^*)$
2.1	.236101	118.0505	13870.63944
2.2	.233066	116.533	13882.39414
2.3	.230186	115.093	13893.85441
2.4	.227449	113.7425	13905.03856

2.5	.224843	112.4215	13915.9631

Table 2. (case 2: When $T_d \leq T < M$) :

Table 2(a): Sensitivity analysis on 's'

S	T_2^*	$Q_2^*\ (T_2^*)$	$Z_2^*\ (T_2^*)$
50	0.276649	27.6649	3317.874602
55	0.286060	28.6060	3336.09602
60	0.294919	29.4919	3353.74254
65	0.303299	30.3299	3370.884971
70	0.311260	31.1260	3387.569617
75	0.318852	31.8852	3403.842535

Table 2(b): Sensitivity analysis on 'c'

C	T_2^*	$Q_2^*\ (T_2^*)$	$Z_2^*\ (T_2^*)$
30	o.276649	27.6649	3317.874601
31	0.273960	27.3960	3423.007294
32	0.271388	27.1388	3528.090614
33	0.268888	26.8888	3633.126891
34	0.266515	26.6515	3738.11829
35	0.264192	26.4192	3843.066807

Table 2(c): Sensitivity analysis on 'h'

H	T_2^*	$Q_2^*\ (T_2^*)$	$Z_2^*\ (T_2^*)$
2.0	0.276649	27.6649	3317.874602
2.1	0.272655	27.2655	3321.741688
2.2	0.268888	26.8888	3325.500375
2.3	0.265326	26.5326	3329.157921
2.4	0.261949	26.1949	3332.721156
2.5	0.258742	25.8742	3336.195986

Table 3. (case 3: When $T_d \leq M \leq T$)

Table 3(a): Sensitivity analysis on 's'

S	T_3^*	$Q_3^*\ (T_3^*)$	$Z_3^*\ (T_3^*)$
100	0.518004	51.8004	1328.854169
110	0.534491	53.4491	1347.91904
120	0.550058	55.0058	1366.797242
130	0.564823	56.4823	1385.191432
140	0.578388	57.8388	1403.122159
150	0.592316	59.2316	1420.632087

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Table 3(b): Sensitivity analysis on 'c'

C	T_3^*	$Q_3^*\ (T_3^*)$	$Z_3^*\ (T_3^*)$
10	0.518004	51.8004	1328.404704
11	0.501594	50.1594	1440.521103
12	0.487090	48.7090	1551.395947
13	0.474141	47.4141	1663.066349
14	0.462479	46.2479	1773.64007
15	0.451900	45.1900	1883.821707

Table 3(c): Sensitivity analysis on 'h'

H	T_3^*	$Q_3^*\ (T_3^*)$	$Z_3^*\ (T_3^*)$
2.0	0.518004	51.8004	1328.404705
2.1	0.510367	51.0367	1328.922617
2.2	0.503170	50.3170	1337.311092
2.3	0.496369	49.6369	1341.579272
2.4	0.489929	48.9929	1345.735161
3.5	0.483817	48.3817	1349.785971

Table 3(d): Sensitivity analysis on 'M'

M	T_3^*	$Q_3^*\ (T_3^*)$	$Z_3^*\ (T_3^*)$
90	0.518004	51.8004	1328.854169
100	0.520417	52.0417	1328.411936
110	0.523059	52.3059	1328.739832
120	0.525930	52.5930	1329.266953
130	0.529004	52.9004	1330.105132
140	0.532293	53.2293	1331.212023
150	0.535783	53.5783	1332.582313

VI. Conclusion

Analysis of the Results shown in tables 1 to 3:

1. It is observed from the computational results shown in table 1(a) that for higher values of ordering cost 's', the corresponding values of replenishment cycle time T_1^*, order quantity $Q_1^*\ (T_1^*)$ and total relevant cost $Z_1^*\ (T_1^*)$ also go higher.
2. The computational results shown in table 1(b) indicate that with the increasing of unit purchasing cost 'c', the corresponding values of replenishment cycle time (T_1^*) order quantity $Q_1^*\ (T_1^*)$ are decreasing while the total relevant cost $Z_1^*\ (T_1^*)$ is increasing with the increasing values of unit purchasing cost 'c'.
3. The computational results shown in table 1(c) indicate that the higher values of holding cost 'h' imply lower values of replenishment cycle time T_1^* and order quantity $Q_1^*\ (T_1^*)$but higher values of total relevant cost $Z_1^*\ (T_1^*)$, the tendency of these results is the same as those shown in table 1(b).
4. The computational results obtained in table 2(a) indicate that ordering cost 's' is directly proportional to the replenishment cycle time (T_2^*), economic order quantity $Q_2^*\ (T_2^*)$ and total relevant cost $Z_2^*\ (T_2^*)$ i.e. an increase in 's' implies the proportional increase in T_2^*, $Q_2^*\ (T_2^*)$and $Z_2^*\ (T_2^*)$.

5 The computational results obtained in table 2(b) indicate that purchasing cost 'c' is inversely proportional to replenishment cycle time (T_2^*) and economic order quantity $Q_2^*\,(T_2^*)$ and directly proportional to the total relevant cost $Z_2^*\,(T_2^*)$ i.e. an increase in 'c' shows proportional decrease in T_2^* and $Q_2^*\,(T_2^*)$ while as increase in $Z_2^*\,(T_2^*)$

6 The computational results obtained in table 2(c) indicate that higher values of holding cost 'h' are associated with the lower values of the replenishment cycle time T_2^* and economic order quantity $Q_2^*\,(T_2^*)$ and higher values of total relevant cost $Z_2^*\,(T_2^*)$.

7 The computational results obtained in table 3(a) indicate that unit ordering cost 's' is directly proportional to all the three values i.e. replenishment cycle time T_3^* and economic order quantity $Q_3^*\,(T_3^*)$ and total relevant cost $Z_3^*\,(T_3^*)$.

8 The computational results obtained 1n table 3(b) show that the value of replenishment cycle time T_3^* and economic order quantity $Q_3^*\,(T_3^*)$ decrease with the increasing of unit purchasing cost 'c' while total relevant cost $Z_3^*\,(T_3^*)$ increase with the increasing values of unit purchasing cost 'c'.

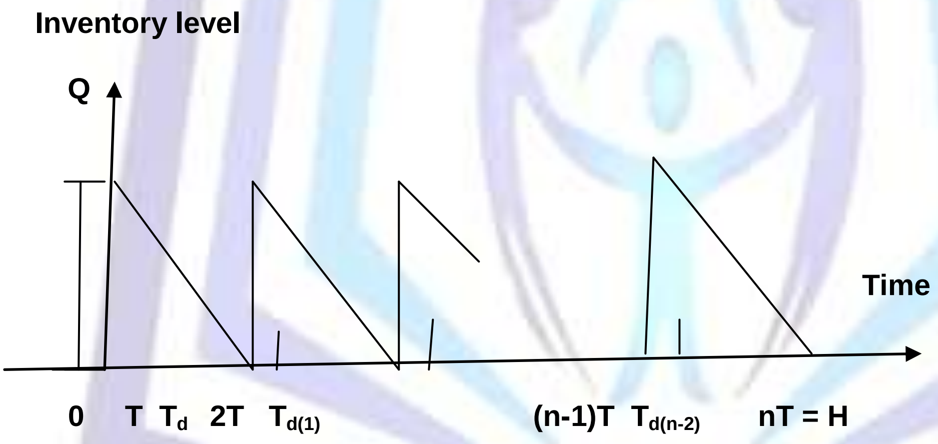
9 The computational results obtained in table 3(c) indicate that higher values of holding cost 'h' imply the lower values of the replenishment cycle time T_3^* and economic order quantity $Q_3^*\,(T_3^*)$ and higher values of total relevant cost $Z_3^*\,(T_3^*)$.

10 The computational results obtained In table 3(d) indicate that higher values of credit period 'M' are associated with higher values of replenishment cycle time T_3^*, economic order quantity $Q_3^*\,(T_3^*)$ and total relevant cost $Z_3^*\,(T_3^*)$.

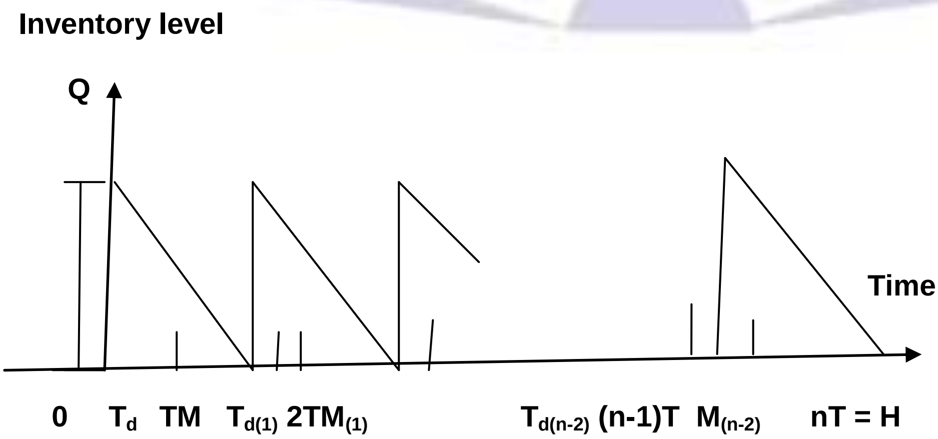
VII. Proposed model

The proposed model can be extended in many more ways such as, we can consider the demand rate in quadratic time dependent form. We can also consider the demand as a function of quantity or selling price. Further the shortages may also be taken in to account to generalize the model thus this paper can be useful developed as a wholesaler and retailer system model.

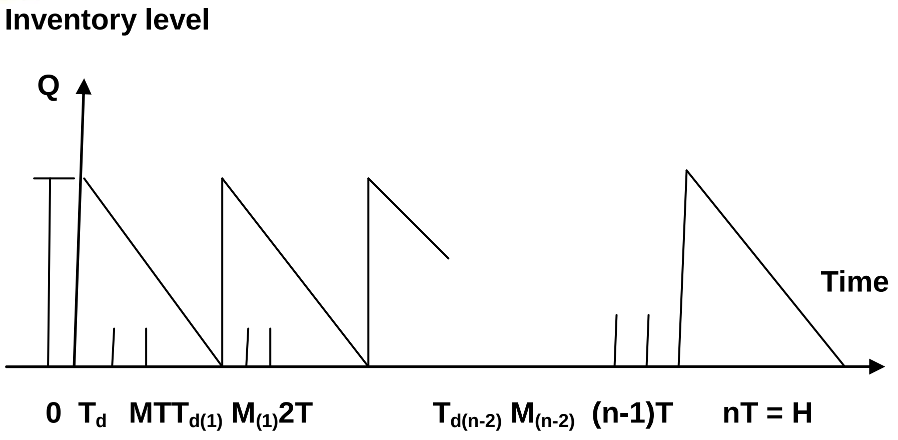
VII. Analysis of Results in Graphical Form



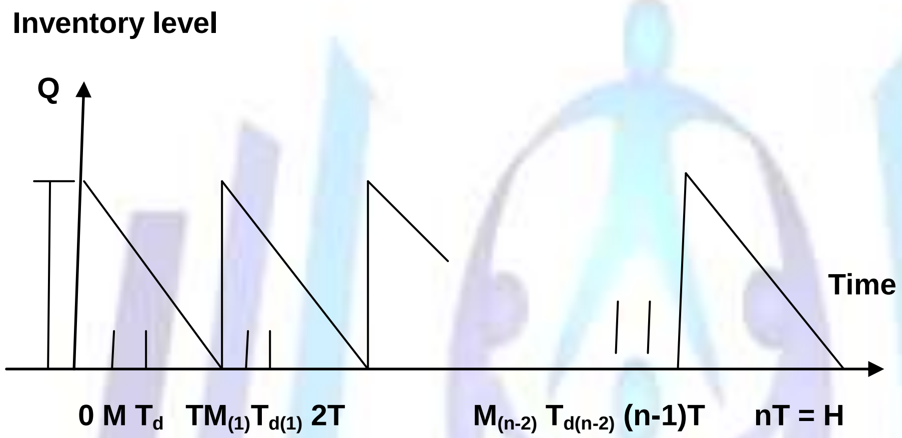
Case 1. $0<T<T_d$



Case 2. $T_d \leq T < M$



Case 3. $T_d \leq M \leq T$



Case 4. $M \leq T_d \leq T$

Fig.1 Four possible inventory systems.

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